December 1964

U.S. FOREST SERVICE
RESEARCH NOTE RM - 34

FOREST SERVICE
U.S. DEPARTMENT OF AGRICULTURE

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

Ground-Cover Changes in Relation to Runoff and Erosion in West-Central New Mexico[1]

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Much has been written of the high sediment content of flows in the Rio Puerco Drainage of New Mexico.[3] This drainage contributes almost half of the measured sediment of the Upper Rio Grande Basin, but less than 8 percent of the water yield.[4]

In 1952 a cooperative study was begun on three watersheds in the Rio Puerco Drainage to (1) determine the feasibility of restoring, through grazing management and land treatments, the more deteriorated portions of this region, and (2) obtain information about the effect of soil and vegetation conservation treatments on water and sediment yields.

Preliminary information on vegetation changes under various seasons of grazing in the semidesert type has been reported.[5] [6] The objective of this paper is to show the effect of these vegetation changes on sediment yields.

Study Area

The San Luis Experimental Site on the Rio Puerco Drainage consists of three contiguous watersheds: WS I, 555 acres; WS II, 471 acres; and WS III, 338 acres. They are located about 58 miles northwest of Albuquerque, in the transition zone between woodland and semidesert grassland. Principal forage species are alkali sacaton (Sporobolus airoides Torr.), galleta (Hilaria jamesii Torr. Benth.), and blue grama (Bouteloua gracilis (H. B. K.) Lag.). Shadscale saltbush (Atriplex confertifolia Torr. & Frem.), other saltbushes (Atriplex spp.), and big sagebrush (Artemisia tridentata Nutt.) comprise the most common shrubs. Some pinyon pine (Pinus edulis Engelm.) and juniper (Juniperus spp.) trees and cholla cactus (Opuntia spp.) are scattered over the area.

[1] *Research reported here was conducted in cooperation with the Bureau of Land Management and the Geological Survey, U. S. Department of the Interior.*

[2] *Research Forester, located at Albuquerque, in cooperation with the University of New Mexico; central headquarters maintained at Fort Collins, in cooperation with Colorado State University.*

[3] *Dortignac, E. J. The Rio Puerco--past, present, and future. N. Mex. Water Conf. Proc. 5: 45-51, illus. 1960.*

[4] *Dortignac, E. J. Watershed resources and problems of the Upper Rio Grande Basin. U. S. Forest Serv., Rocky Mountain Forest and Range Expt. Sta., 107 pp., illus. 1956.*

[5] *Hickey, Wayne C., Jr., and Garcia, George. Range utilization patterns as affected by fencing and class of livestock. U. S. Forest Serv. Res. Note RM-21, 7 pp., illus. 1964.*

[6] *Hickey, Wayne C., Jr., and Garcia, George. Changes in perennial grass cover following conversion from yearlong to summer-deferred grazing in West Central New Mexico. U. S. Forest Serv. Res. Note RM-33, 3 pp. 1964.*

Average annual precipitation is close to 10 inches.[6] The headwaters of the watersheds originate on mesas that break off into steep rocky slopes. These breaks give way to rolling foothills that merge with the alluvial bottoms. A layer of Mesa Verde sandstone overlies Mancos shale. The sandstone breaks and underlying shales form the parent soil material, the texture of which varies from sandy loams to silty clays. The area, which ranges in elevation from 6,500 to 7,000 feet, is typical of the large semiarid area in northwestern New Mexico.

Methods

Runoff and sediment[7] were measured by methods similar to those described by Peterson.[8] Reservoirs constructed to catch runoff and sediment from the watersheds were equipped with a water-stage recorder. Sediment was determined from periodic surveys of the reservoirs to determine area, and from these data capacity curves were developed. The difference in capacity between surveys represents sediment changes. No adjustment was made for sediment that might have passed through an outlet pipe on WS II or through the spillway (at time of overflow). These amounts are considered to be only a small percentage of the total. Moreover, no adjustment was made for compaction of sediment in the reservoirs. Trap efficiency of the reservoirs is not known.

Precipitation and ground-cover measurements are fully described elsewhere.[6] Essentially, the ground-cover measurements consisted of 24 randomly distributed clusters of three 100-foot transects on each of the three watersheds.[9] Both recording and open standard rain gages were used to measure precipitation.

[7] *All runoff and sediment figures used in this paper were prepared by U. S. Geological Survey.*

[8] *Peterson, H. V. Hydrology of small watersheds in the western states. U. S. Geol. Survey Water-Supply Paper 1475-I. 356 pp., illus. 1962.*

[9] *Parker, K. W. A method for measuring trend in range condition on National Forest ranges. U. S. Forest Serv., Washington, D. C. 26 pp., illus. 1951.*

Grazing use on the experimental watersheds has been described by Hickey and Garcia.[6] Before 1957 the unfenced watersheds were grazed by cattle yearlong; during 1957-58 they were grazed only during the winter (November-April). Since 1958 grazing has consisted of overwinter (November 1 to May 1) use only. Animals have been confined by fences to individual watersheds. The objective is to attain 55 percent utilization by weight of the principal forage species, alkali sacaton.

Results

Comparison of the average annual sediment production during the two periods, 1953-58 and 1959-62, showed a decrease on each of the three watersheds (table 1). Because of the time and manner in which the data were col-

Table 1.--Sediment deposition as measured by changes in reservoir capacity,[1] San Luis watersheds, 1952-62[2]

Survey dates	WS I	WS II	WS III
	--	Acre-feet	--
August 1952-November 1954	0.54	1.09	0.44
June 1956	1.17	.48	.64
August 1956	.59	.51	.52
July 1957	[3] +.14	.18	.15
August 1957	.44	.16	.20
June 1958	1.91	2.71	.34
October 1958	.08	.11	.27
Total	4.59	5.24	2.56
Average per year (6 years)	.8	.9	.4
October 1959	[3] +.24	.26	.32
May 1960	.05	0	.12
October 1960	0	0	0
July 1962	.56	.73	.28
Total	.37	.99	.72
Average per year (4 years)	.1	.2	.2

[1] Values often were measured to two decimal places, but should be considered accurate to only one decimal place.

[2] Data for 1952-59 published by Peterson.[8]

[3] Capacity of reservoir increased because sediment dried between measurements.

lected, the observed differences in mean value for the two periods cannot be tested for statistical significance.

Ground-cover measurements for the three principal grass species, rock, litter, and bare soil show a loss of ground cover on all watersheds between the years 1952 and 1958 (table 2). During this period litter on WS I and WS II decreased. Bare soil increased on WS I and II, but remained about the same on WS III. The effect of rock, measured on transects, on the hydrology of the area is unknown.

Ground cover and litter increased markedly after 1958, while bare soil decreased. All of the differences are significant at the 1 percent level. Rock occurrence showed a slight increase during this period.

Neither total annual precipitation nor precipitation measured during the growing season, May 1 to November 1, were significantly different between the two periods (table 3).

Covariance analysis with precipitation as covariate showed no difference in seasonal runoff between periods (table 3).

Summary

In 1952 a cooperative study on three San Luis Experimental watersheds in New Mexico was begun to determine the feasibility of restoring the more deteriorated portions of this region. Grazing management was started, but full control of the livestock through overwinter use only was not achieved until 1958. The periods 1952-58 and 1959-62 have been examined to determine the effect this different grazing use had on sediment yield, surface runoff, and ground cover.

Before the uniform grazing treatment, average ground cover, measured by three key grass species, ranged from 3 to 5 percent on the watersheds. Three years later the percentages had doubled: they ranged between 6 and 12 percent; bare ground decreased. Runoff during periods was similar, although the precision of the measurements was such that small changes could not be detected. Sediment production decreased between 0.2 and 0.7 acre-foot per year on the watersheds. The changes may be attributable to the change in grazing use between periods. Ground cover improved under summer-deferred grazing and fencing. Precipitation averages during the two periods were similar.

Table 2.--Ground cover index[1] of principal perennial grass species, rock, litter, and bare soil in each of the years measured

Substance	WS I			WS II			WS III		
	1952	1958	1961	1952	1958	1961	1952	1958	1961
	Percent								
Galleta	2.92	3.22	6.60	2.13	1.42	3.49	1.75	1.17	2.18
Alkali sacaton	1.00	.56	2.21	1.51	1.06	3.45	2.47	1.67	3.17
Blue grama	3.28	1.47	3.15	1.26	.48	.96	.36	.19	.53
Total grass	7.20	5.25	11.96	4.90	2.96	7.90	4.58	3.03	5.88
Rock	4.44	2.26	4.33	6.83	6.02	8.50	2.42	3.47	5.65
Litter	6.14	2.94	12.31	5.94	5.33	14.65	3.83	4.40	11.32
Bare soil	70.17	82.04	68.05	65.52	77.93	63.72	79.67	80.96	74.20

[1] Occurrence of a basal portion of a plant, litter, bare soil or rock within 3/4-inch loops placed at 1-foot intervals along a 100-foot transect. Litter, bare soil, or rock must occupy half or more of the loop area to be counted (from Parker [9]).

Table 3.--Precipitation, annual and growing season, and seasonal runoff on San Luis watersheds, 1954-62

Year	WS I			WS II			WS III		
	Precipitation		Seasonal runoff[3]	Precipitation		Seasonal runoff[3]	Precipitation		Seasonal runoff[3]
	Annual[1]	Growing season[2]		Annual[1]	Growing season[2]		Annual[1]	Growing season[2]	
	Inches		Acre-feet	Inches		Acre-feet	Inches		Acre-feet
1954	11.16	7.20	19.90	13.10	9.30	19.80	12.10	8.22	33.89
1955	6.70	5.79	34.88	7.19	6.35	24.77	6.69	5.72	15.28
1956	6.12	2.28	6.86	6.21	2.20	10.04	5.44	2.16	4.15
1957	13.29	9.30	89.19	12.05	8.16	88.62	11.34	7.58	58.67
1958	11.68	5.66	7.57	12.72	6.44	17.20	11.61	7.49	35.74
Average	9.79	6.05	31.68	10.25	6.49	32.09	9.44	6.23	29.55
1959	10.53	6.71	18.64	10.72	6.84	24.28	10.72	6.87	21.82
1960	11.74	5.53	13.10	8.48	5.42	14.19	10.62	5.04	10.03
1961	10.40	9.39	31.81	10.60	9.59	44.83	9.95	8.94	37.87
1962	6.78	3.16	11.17	6.25	2.32	2.92	6.38	2.62	2.24
Average	9.86	6.20	18.68	9.01	6.04	21.56	9.42	5.87	17.99

[1] Water year is November 1 - October 31; e.g., 1954 is November 1, 1953 - October 31, 1954.
[2] May 1 - November 1.
[3] April 1 - November 1. Storms outside these dates are usually winter-type storms. Since most winter storms producing runoff were not measured during the study, the few recorded ones were omitted from the table.